CMOS transceivers for compact architectures and nL to sub-nL high performance NMR micro-sensor

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CMOS technologies allow for the implementation of miniaturized electronics and they can be used to realize pulsed NMR probes that are compact and versatile.

Compact NMR Probes

Single-chip CMOS transceivers have been interfaced with external (i.e., off-chip) excitation-detection resonators, proving to be valuable tools for the manufacturing of compact instrumentation.

In probes with sample volumes ranging from a few μL down to 100 nL, such configuration delivered state-of-art performance and was used to demonstrate high-resolution multi-nuclear measurements [1] and broadband magnetometry, also including quadrature detection capabilities [2].

Single head multinuclear spectroscopy

Custom Multichannel Probes for simultaneous field monitoring

CMOS chips interfaced with external resonators simplify the construction of compact NMR probes, reduce their costs, and enable novel architectures.

Ultra-Compact NMR Probes

CMOS technologies can also be used to implement ultra-compact probes, where multilayer micro-coils are co-integrated on the same chip with the transceiver electronics. This type of probe allows for an exceptional degree of versatility and state-of-art performance for the analysis of microscopic samples, i.e. having volumes ranging from 10 nanoL down to 100 picoL.

By using an ultra-compact probe having a sensing region of about 200 picol and a spin sensitivity of $1.5 \times 10^{13}$ spins/Hz$^{1/2}$ at 7 T we demonstrated direct reading of endogenous compounds in sub-nanoL eggs of microorganisms [3].

More recently, the combination with cutting-edge microfabrication techniques also allowed for spectroscopy of sub-sections of intact C. elegans worms [4].

Outlook

High-sensitivity CMOS based NMR micro-sensors will enable parallelized NMR on populations of samples that are currently out of reach, such as large unicellular microorganisms, micro-tissues derived from stem-cells, and even mammalian embryos (humans included).

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